**THE UPPER CONTACT UNIT (ROOF ROCKS) OF THE SUDBURY IGNEOUS COMPLEX, NORTH RANGE, SUDBURY IMPACT STRUCTURE.** L. E. Debono[1], G. R. Osinski[1, 2], and R. A. F. Grieve[1]. [1]Centre for Planetary Science and Exploration/Dept. of Earth Sciences, University of Western Ontario, Canada, [2]Dept. of Physics and Astronomy, University of Western Ontario, Canada

**Introduction:** The 1.85 Ga Sudbury Igneous Complex (SIC) is the erosional remnant of the tectonized impact melt sheet of the Sudbury impact structure [1]. During post-impact cooling, the impact melt sheet differentiated into four main units that comprise the SIC (from bottom to top): the Sublayer, Norite, Quartz Gabbro, and Granophyre [2]. Overlying the SIC is the Sandcherry Member of the Onaping Formation, a complex series of breccias in the Whitewater Group.

A characteristic of impact melt sheets is the presence of a chilled phase (roof rocks) at the uppermost contact [1]. Compared to the melt sheet at depth, the upper reaches of the melt will experience relatively rapid cooling via radiative heat losses and thermal equilibration with the greater abundance of cooler clasts from fallback debris [1]. The combined effects, thus, result in relatively finer grained clast rich melt rocks at the upper reaches of the melt sheet. Due to relatively rapid crystallization, the roof rocks of the SIC would geochemically represent the initial composition of the SIC prior to differentiation [1].

Until recently, there has been very little to no recognition of a suite of roof rocks overlying the Granophyre of the SIC [2, 3]. However, clast-rich igneous bodies at the contact between the Granophyre and the overlying Onaping Formation, previously referred to as “Onaping Intrusion” [4], were studied in two drill cores from the North Range of the SIC by Anders et al. [3] and proposed to be the missing roof rocks of the SIC. In this study, we have built upon the preliminary, geographically limited study of Anders et al. [3] and conducted a targeted investigation of the OI throughout the entire North Range of the SIC. We conclude the OI fits the criteria of roof rock to the SIC and recommend that the so-called “Onaping Intrusion” be termed the “Upper Contact Unit” (UCU) of the SIC [3].

**Methods**: Field work was carried out across the extent of the North Range in the summers of 2016 and 2017. Field work included sample collection in both dispersed and traverse fashion. A total of 114 samples were collected, of which 46 thin sections were made and observed using an Olympus BX51 microscope. Energy dispersive spectroscopy (EDS) and backscattered electron (BSE) imagery was carried out on 20 samples on a JEOL JXA-8530F field emission electron microscope. Semi quantitative analysis was used to confirm mineral phases using EDS. Entire thin sections were scanned using BSE and subjected to semi-automatic image analysis using ImageJ software to analyze K-spar grain size in the UCU. X-ray fluorescence whole rock geochemical analysis was carried out on 17 samples. UCU samples were carefully selected based on having little to no visible clasts in the matrix at the hand sample scale.

**Results:**

*Field Work.* The UCU located distally from the Granophyre contact exhibits a fine-grained igneous matrix, containing 20-40% clasts that range in size from mm-scale to ~5 m. Proximal to the granophyre contact, the matrix is coarser grained and contains <5% clasts ranging in size from mm-scale to 10 cm. Locally clast-free patches occur sporadically throughout the matrix. Throughout the UCU, ~15% of clasts are quartzite and ~85% are granitic and are sub-rounded to rounded. Clast boundaries are either sharp with the matrix or exhibit reaction rims, consistent with chemical and/or thermal reactions at the clast-matrix interface. Oxidized sulfides metal “blebs” are found suspended within the matrix, and are <5 cm in diameter. The sulfide blebs comprise 1-5% of the total “clast” abundance. The contact between UCU and the Granophyre is gradational.

*Petrography.* Table 1 shows the predominant mineral phases and their respective modal percentages throughout the UCU matrix.

Table 1: UCU matrix mineral phases.

| Mineral phase | Size (μm) | Modal % |
|---|---|---|
| Quartz, sub- to euhedral | 5 - 500 | 30 - 50 |
| Plagioclase, sub- to euhedral laths | 10 - 600 | 15 - 30 |
| K-spar, subhedral | 5 - 400 | 5 - 25 |
| Amphibole, subhedral laths | 5 - 700 | 10 - 15 |
| Clinopyroxene, an- to subhedral | 10 - 20 | 5 - 10 |
| Sulfides, an- to subhedral | 10 - 400 | <5 |

The skeletal intergrowth of feldspar and quartz is the pervasive texture throughout the matrix. Granophyric intergrowths of feldspar and quartz also occur in UCU samples collected proximal to the Granophyre contact. Some quartz grains exhibit at least two orientations of highly decorated planar deformation features (PDF), as observed on the flat stage. Alteration is evidenced by chloritization and epidotization of amphibole and pyroxene. Pervasive alteration of plagioclase occurs in most samples as saussuritzation. The UCU Matrix grain size coarsens towards the Granophyre contact, shown by image analysis of K-spar grain sizes used as a representative proxy in this study (Fig. 1).

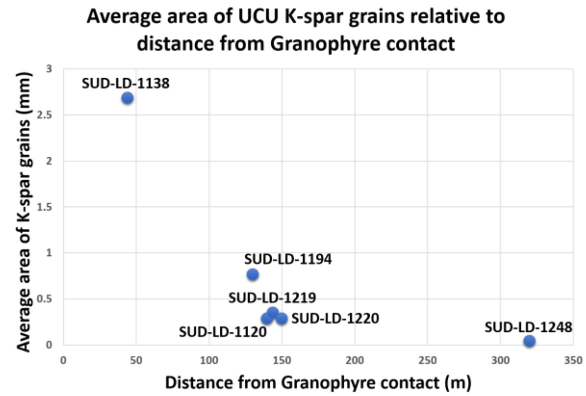


*Fig. 1. Semi-automatic image analysis results of K-spar grain sizes relative to the Granophyre contact.*

Mafic clasts up to 1 mm in size occur sparsely throughout the matrix. Their sparse occurrence and small size is attributed to preferential partial melting of mafic phases. Clasts are generally sub-rounded to rounded and are commonly surrounded by reaction rims. Felsic clasts have either felsic or mafic reaction rims, and occasionally no reaction rim. Mafic clasts are only observed with felsic reaction rims. Overall clast abundance tends to decrease towards the Granophyre contact.

*Geochemistry*. Fig. 2a, b shows rare earth and major oxide XRF data of the UCU from this study combined with previous UCU data [7, 10], compared with the geochemical composition of the SIC and Offset Dykes. Fig. 2a shows that the REE pattern of the UCU is most similar to that of the Offset Dykes but with relatively lower abundances. This comparison also begs the question of whether the Offset Dykes [11] or the UCU represent the initial composition of the SIC. The UCU and Offset Dykes show a negative Eu anomaly. If either represent the initial composition of the SIC, then this anomaly is inherent of the SIC. Major oxide compositions in Fig. 2b show that the average UCU is compositionally more mafic than the average SIC and most comparable to the Norite and Offset Dykes. The close compositional relationship between the UCU and Offset Dykes further questions which unit represents the initial composition of the SIC. It is important to note that the geochemical composition of the UCU is influenced by the abundance and degree of assimilation of clasts in the matrix.

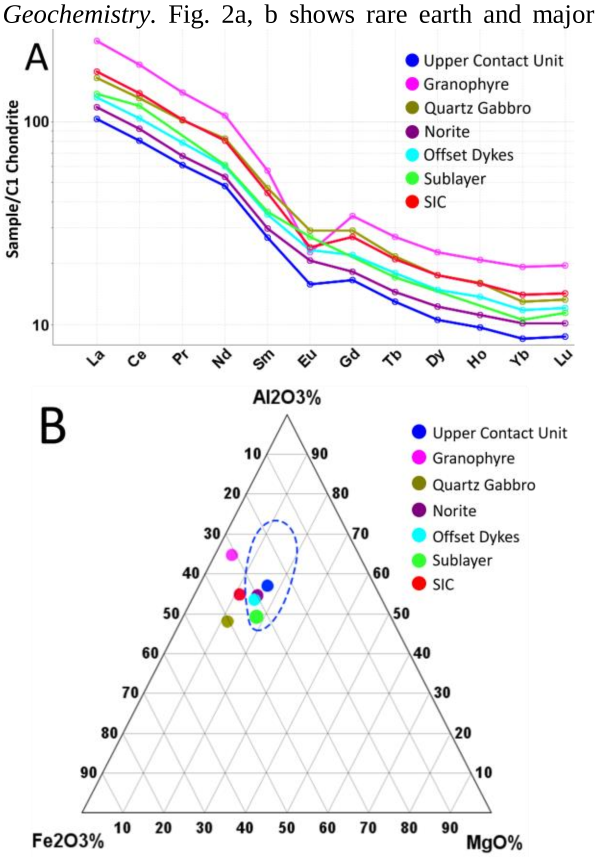


*Fig 2. (A) REE (normalized to C1 Chondrite [5]) and (B) major oxide data for average NR SIC units [2, 6] and Offset Dykes [7, 8, 9]. Dashed line indicates UCU variability.*

**Discussion and conclusion:** The rapid quenching and crystallization, igneous texture, clast abundance and grain size trends, stratigraphic position, and geochemistry of the UCU are all consistent with it being the melt sheet roof rocks for the SIC. The presence of PDFs in quartz hosted in the UCU further suggests that the UCU is an impact melt rock by definition. Previously recorded thickness variations in the SIC [12] may be associated with variations in cooling, and appear to correlate with the presence or absence of the insulating UCU roof rock. The results in this study and combined previous findings indicate that the UCU should no longer be recognized as a unit within the complex breccias of the Onaping Formation, but rather the upper member of the SIC. Therefore, “Upper Contact Unit” of the SIC is the most appropriate term and the use of “Onaping Intrusion” for this lithology should be abandoned.

**References:** [1] Grieve et al. (2010) *Meteoritics & Planet. Sci., 50,* 1577–1594. [2] Therriault et al. (2002) *Econ. Geol., 97,* 1521–1540. [3] Anders et al. (2015) *Meteoritics & Planet. Sci., 50.* 1577–1594. [4] Ames et al. (2008) *Econ. Geol., 103.* 1057–1077. [5] Sun and McDonough (1989) *GSL. 42.* 313–345 [6] Naldrett et al. (1984) *OGS. Spec. Vol.* [7] Anders (2016) *UWO.* PhD Data. [8] Coulter (2016) *UWO.* MSc Data. [9] Pilles (2016) *UWO.* PhD Data. [10] Brillinger (2011) *UWO.* BSc Data. [11] Lightfoot et al. (1997) *Econ. Geol. 92.* 289–307 [12] Dreuse et al. (2010) *Terr. Nov. 22.* 463–469.

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